

Infrastructure Economics

OLLI – University of Nevada, Reno
May 20, 2022
Jon D. Haveman, Ph.D.



Available NEED Topics Include:

- Coronavirus Economics
- Climate Change
- Economic Inequality
- Economic Mobility
- US Social Policy
- Trade and Globalization
- Minimum Wages
- The U.S. Economy
- Immigration Economics
- Housing Policy
- Federal Budgets
- Federal Debt
- Black-White Wealth Gap
- Autonomous Vehicles

Course Outline

- **Contemporary Economic Policy**

- Week 1 (4/1): US Economy & Coronavirus Economics
- Week 2 (4/15): Trade and Globalization (Alan Deardorff, Univ. of Michigan)
- Week 3 (5/6): Cryptocurrencies (Geoffrey Woglom, Amherst College)
- **Week 4 (5/20): Infrastructure Economics (Jon Haveman)**

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Credits and Disclaimer

- **This slide deck was authored by:**

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- Jon Haveman, NEED

- **Disclaimer**

- NEED presentations are designed to be nonpartisan.
- It is, however, inevitable that the presenter will be asked for and will provide their own views.
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Outline

- What do we mean by infrastructure?
- Current state of infrastructure in the US
- Infrastructure in economic models
- Why should we invest in infrastructure?
- Policy options to fund infrastructure investments



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What is a Useful Definition of Infrastructure?

- *Infra-* means "below;"
 - So, infrastructure is the "underlying structure" of a country and its economy.
- Miriam-Webster definition of Infrastructure:
 - the system of public works of a country, state, or region
 - *also*: the resources (such as personnel, buildings, or equipment) required for an activity
 - the underlying foundation or basic framework (as of a system or organization)



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Different Kinds of Infrastructure (& Examples)

- **Provide basic services.**
 - Electricity, water, broadband (?).
- **Improve the performance of the economy.**
 - Roads, bridges, airports, seaports.....
 - General R&D?
 - Education
- **Make people's lives better.**
 - Roads, bridges, airports...
 - Protection from natural disaster
 - Child care, education.



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Another Categorization

- **Tangible**
 - Traffic systems: streets, railways, other transportation
 - Utilities and disposal: energy, water, and communication networks
- **Intangible**
 - Human capital
 - Education, research facilities
 - Health systems, social services
- **Institutional**
 - Legal, economic, and social system
 - Culture, traditions



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Infrastructure – Is it:

- **Traditional:**
 - Roads, bridges, tunnels, airports, seaports, dams, water, electrical, and telephone systems?
- **Additional:**
 - Broadband
- **What about:**
 - R&D? Human capital? Institutions?
- **What definition of “infrastructure” makes it most useful today?**
 - Caregiving? Are people a part of the basic economic infrastructure?



What is Infrastructure? – Our Focus Today

- **Economic infrastructure:**
 - Basic services that represent foundational tools for the economy.
 - Can be:
 - Physical structures
 - Systems
 - Institutions
 - Services
 - Facilities
- **We will focus on physical structures, systems, and facilities.**



Categories of Physical Infrastructure

- **Transportation**
 - Highways, roads, bridges
 - Mass transit
 - Airports, seaports
- **Water**
 - Supply
 - Distribution
- **Waste management**
 - Trash, recycling, and wastewater
- **Energy**
 - Generation
 - Transmission
- **Communications**
 - Telephone
 - Internet


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Current State of Infrastructure in the US

2021 Infrastructure Grades

 AVIATION	↑ D+	 PORTS	↑ B-
 BRIDGES	↓ C	 RAIL	B
 DAMS	D	 ROADS	D
 DRINKING WATER	↑ C-	 SCHOOLS	D+
 ENERGY	↑ C-	 SOLID WASTE	C+
 HAZARDOUS WASTE	D+	 STORM WATER	D
 INLAND WATERWAYS	↑ D+	 TRANSIT	D-
 LEVEES	D	 WASTEWATER	D+
 PARKS AND RECREATION	D+		

America's Cumulative Infrastructure Grade



A	EXCEPTIONAL
B	GOOD
C	MEDIOCRE
D	POOR
F	FAILING

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Current State of Transportation Infrastructure

• Roads

- Over 4 million miles of roads.
- In 2018: 3.3 trillion VMT (Vehicle Miles Traveled).
- 40%+ of America’s urban interstates are congested.
- In 2017, 8.8 billion hours of traffic delay.
 - o Costing the country \$166 billion in wasted time and fuel.

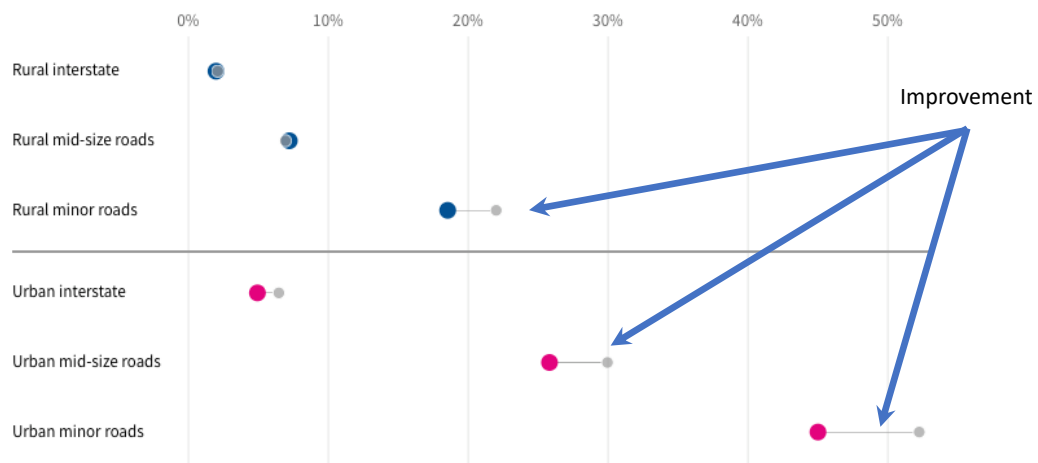
“The average auto commuter spends 54 hours in congestion and wastes 21 gallons of fuel due to congestion at a cost of \$1,080 in wasted time and fuel.”

-- 2019 Urban Mobility Report, Texas A&M Transportation Institute

- 42,915 motor vehicle fatalities in 2021 (16 year high).

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But it is Getting Better



PERCENT OF ROADS IN UNSATISFACTORY CONDITION 2000 VS 2019

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Current State of Transportation Infrastructure

• Mass Transit

- ~ 6,800 organizations in the U.S. that provide transit services.
- Transit ridership: peaked at 10.7 billion in 2014.
 - o COVID-19 pandemic caused major disruptions across all transit agencies..
- 45% of Americans have no access to transit.
- 50% of passenger trips by bus.
 - o 10% of fleets NOT in “state of good repair”.
- 33+% by heavy rail (subway/metro)
 - o 3% of fleets NOT in “state of good repair”.

Transit users face increased delays due to service interruptions, and agencies are grappling with growing maintenance and vehicle procurement costs.



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Current State of Transportation Infrastructure

• Aviation

- In 2019, 10 million+ commercial flights
 - o Flying ~3 million passengers daily
- National Plan of Integrated Airport Systems (NPIAS)
 - o identifies over 3,300 airports in the U.S. aviation network
- Contributed 5.1% to US GDP
 - o Generated 10.6 million jobs
- In 2019, 21% of flights were delayed. Delays were caused by
 - o late-arriving aircraft,
 - o air carriers,
 - o weather, and
 - o diverted flights.



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Current State of Transportation Infrastructure

• Sea Ports

- 99% of US overseas trade (by weight) passes through ports.
- Los Angeles and Long Beach – busiest ports in the US.
 - o Top 10 U.S. ports account for 3/4th of U.S. trade
- Congestion decreased port productivity by over 25% over the past decade
 - o COVID-19 pandemic exacerbated the congestion related issues
- Port infrastructure upgrades needed to accommodate new, larger ships
 - o need deeper navigation channels

• Waterways

- More than 600 million tons of cargo
 - o 14% of annual domestic freight
- Beyond their 50-year design life
- 50% vessels experience delays due to maintenance shut downs



Current State of Water Infrastructure

• Drinking Water

- 150,000+ public drinking water systems.
- 1 billion+ glasses of drinking water consumed daily.
 - o 80% from surface waters such as rivers, lakes, oceans, reservoirs.
 - o 20% from groundwater aquifers.
- Delivered via 2.2 million miles of pipes.
 - o Majority laid in mid-20th century and are aging.
 - o An estimated 240,000 water main breaks occur each year.
 - o 6 billion gallons of treated drinking water lost daily due to leaking pipes.
 - Could support 15 million households.



Current State of Water Infrastructure

• Wastewater

- 16,000+ wastewater treatment plants.
 - 1.3 million miles of public and private lateral sewers.
- Used by 80% of Americans.
 - Likely to serve 56 million more people by 2032.
- Structural failure, blockages, and overflows cause at least 23,000 to 75,000 sanitary sewer overflow events each year.



Current State of Water Infrastructure

• Dams

- There are over 91,000 dams in the US providing:
 - drinking water,
 - irrigation,
 - hydropower,
 - flood control, and
 - recreation
- Most are privately owned
- Average age – 57 years
- By 2025, 7 out of every 10 dams will be over 50 years old
- In 2019, there were 15,600 high-hazard potential dams



Current State of Water Infrastructure

• Levees

- A network of 30,000 miles of levees.
- Levees in the U.S. Army Corps of Engineers Levee Safety Program protect:
 - o over 300 colleges and universities,
 - o 30 professional sports venues,
 - o 100 breweries, and
 - o an estimated \$1.3 trillion in property.
- Built in the mid-20th century with an average age of 50 years, aging fast.
- Levees are crucial with majority of the U.S. population living within 50 miles of a coast.

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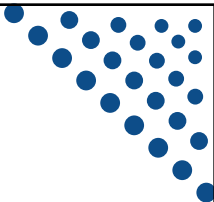
How Do We Compare?

Countries With The Best Infrastructure


Rank	Country	Infrastructure Score
1	Hong Kong	6.7
2	Singapore	6.5
3	Netherlands	6.4
4	Japan	6.3
5	United Arab Emirates	6.3
6	Switzerland	6.3
7	France	6.1
8	Korea	6.1
9	United States	6.0
10	Germany	6.0
11	United Kingdom	6.0
12	Spain	5.9

We're #9!

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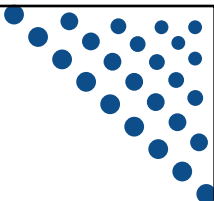


The 2021 Infrastructure Package


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What was in it?

• Transportation

Roads, bridges, major projects	\$110 Billion
Passenger and freight rail	\$66 Billion
Public transit	\$39 Billion
Airports	\$25 Billion
Port infrastructure	\$17 Billion
Transportation safety programs	\$11 Billion
Electric vehicles	\$7.5 Billion
Zero and low-emission buses and ferries	\$7.5 Billion
Revitalization of communities	\$1 Billion

• Other

Broadband	\$65 Billion
Power infrastructure	\$73 Billion
Clean drinking water	\$55 Billion
Resilience and Western water storage	\$50 Billion
Removal of pollution from water and soil	\$21 Billion


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How is it paid for?

- Unspent emergency relief funds
- Strengthening tax enforcement – crypto currencies
- Revenue generated from higher economic growth
- Increased federal budget deficit



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What is missing?

- **Strategic thinking:**
 - Long term thinking, planning, prioritizing.
- **Meaningful climate resilience planning.**
- **Education & R&D.**
- **Expanding/insuring water supplies.**
- **Hazardous waste.**
- **Support for human beings.**



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Infrastructure Benefits



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Infrastructure in economic models

- **Vast macroeconomic literature on relation between infrastructure and economic growth.**
- **Wide variation in the magnitude of economic effects of infrastructure spending on growth or productivity.**



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Why Should we Invest in Infrastructure?

• Vital ingredient to economic growth

- Facilitates economies of scale, raises productivity.
A 10% rise in infrastructure assets directly increases Real GDP per capita by 0.7 – 1%.
 - o Assuming increases in spending translate 1-1 to the stock of assets:
 - ~\$50 billion will raise GDP per capita in the US by ~\$300 - \$450.
 - **\$100 to \$150 billion** in increased GDP.
 - o Productivity growth raises standards of living.



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Why Should we Invest in Infrastructure?

• Vital ingredient to economic growth

- Reduces trade costs by improving access to markets.
 - o Port capacity improvement
 - o Reducing traffic congestion
- Reduces effective distances, facilitates trade and agglomeration.
- Advances public health by providing clean water and effective sewage systems.



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Case for Spending More on Infrastructure Maintenance

- **Rundown infrastructure increases costs**

- Longer travel time → higher costs for businesses
- Wear on cars → more spending on car repairs → faster car depreciation
- Vehicle deterioration → Additional fuel consumption

“The average motorist in the U.S. is losing \$523 annually -- \$112 billion nationally -- in additional vehicle operating costs as a result of driving on roads in need of repair.”

-- November 2016 Urban roads TRIP report

- **Deferred maintenance is a debt burden on the future generations.**



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Public or Private Infrastructure Investment?

- **Nonrival consumption**

- **Non-excludable use**

→ Social benefits might exceed expected financial return.

→ Private sector likely to underprovide key types of infrastructure.

→ Economic case for public provision of infrastructure assets.



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Public or Private Infrastructure Investment?

- **A few arguments for public provision:**

- Provision of public infrastructure increases productivity of private infrastructure
 - o Incentivizes private capital investment,
 - o Increases labor productivity,
 - o Indirectly increases employment and wages.



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Public or Private Infrastructure Investment?

- **A few more arguments for public provision:**

- Provides short-term stimulus to the economy by creating jobs
- Promotes trade and commerce
- Promotes equity
 - o Pays prevailing wages
 - o More demographically inclusive
 - o Encompasses all congressional districts
- Promotes public health and well-being
- Improves public safety
- Affects not just the present but the future generations also

- **Some of these are more debatable than others**



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Empirical Evidence on Effect of Gov't Investment

- **In studies from 80s, early 90s:**
 - A 1% increase in the stock of public capital raised GDP by 0.39%
- **In more recent studies**
 - by only 0.08% in the short run, 0.12% long run
- **In terms of multiplier, most short-term estimates are less than 1**
 - Due to negative effects of tax/interest rate increases on private C and I
- **Longer term multiplier**
 - OECD panel data – 1.6
 - US interstate highway system – 1.8



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Empirical Evidence on Effect of Gov't Investment

- **Estimates from the 2009 American Recovery and Reinvestment Act**
 - Each \$100,000 spent led to 0.8 job-years created
 - Highway construction employment unaffected in 2009-10
 - o fell sharply afterwards
 - Significant “crowd-in” of state and local highway spending
 - o For each \$1 of federal grant and additional \$2.30 in state spending

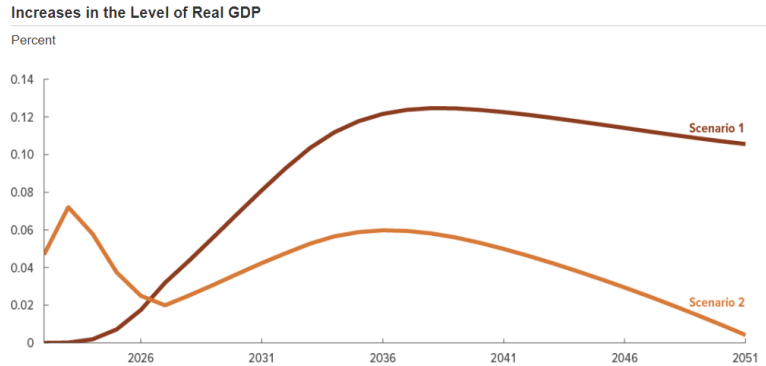


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A CBO study on effects of Gov't Investment in Infrastructure on Real GDP

• **Two scenarios to finance \$500 billion over 10 years:**

1. Reducing gov't noninvestment purchases
 - **Reduces** net cost by 1/3rd
 - Real GDP increase averages 0.09% between 2022-51
2. Increasing federal borrowing
 - **Increases** net cost by 1/4th
 - Real GDP increase averages 0.04% between 2022-51

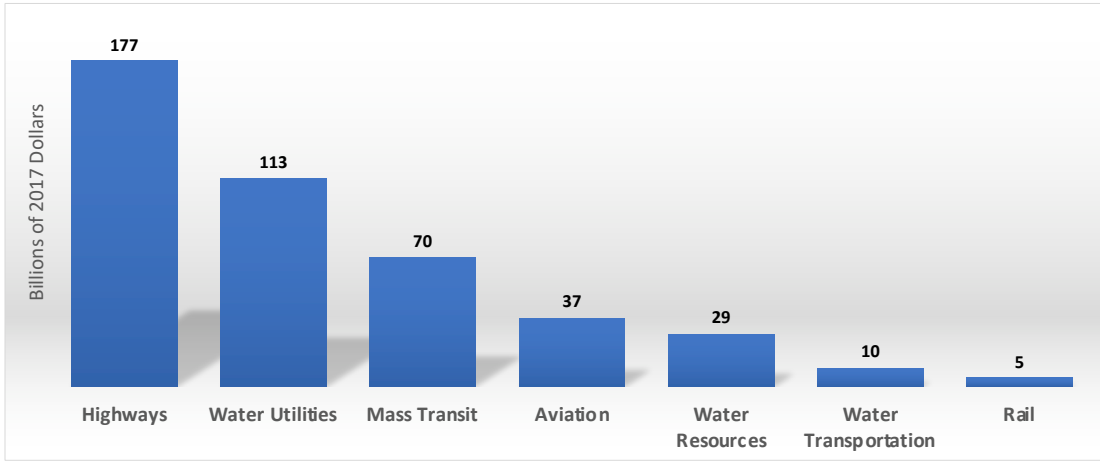


* A \$1 increase in infrastructure spending increases GDP by 9.2 cents. 11 years to recoup the investment.

Infrastructure Investment in the US

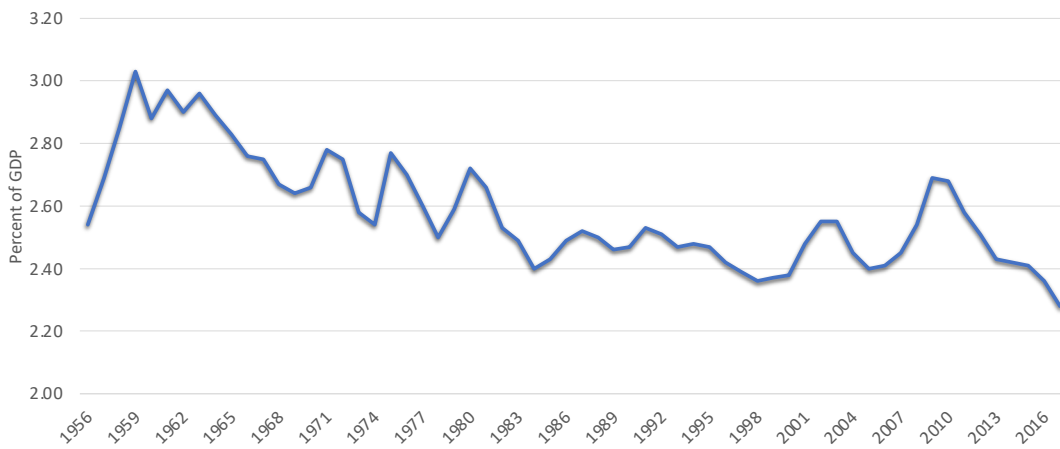
- **Transportation, drinking water, and wastewater infrastructure**
 - mainly funded by the public sector
- **Publicly owned transportation infrastructure**
 - Highways
 - Aviation
 - Rail
 - Mass transit
 - Water transportation
- **Publicly owned water infrastructure**
 - Water utilities
 - Water resources
- **In 2017, Federal, State and Local governments spent**
 - \$441 billion on infrastructure
 - 2.3% of gross domestic product

Government Spending on Infrastructure, 2017

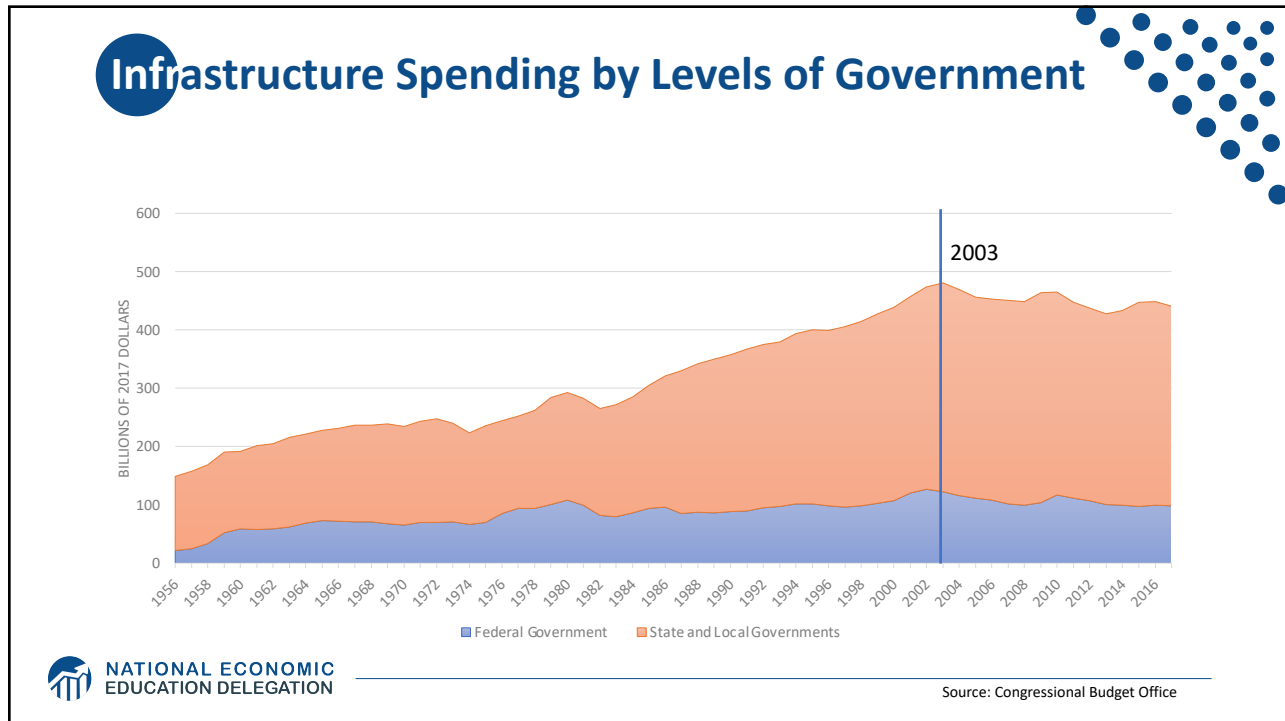


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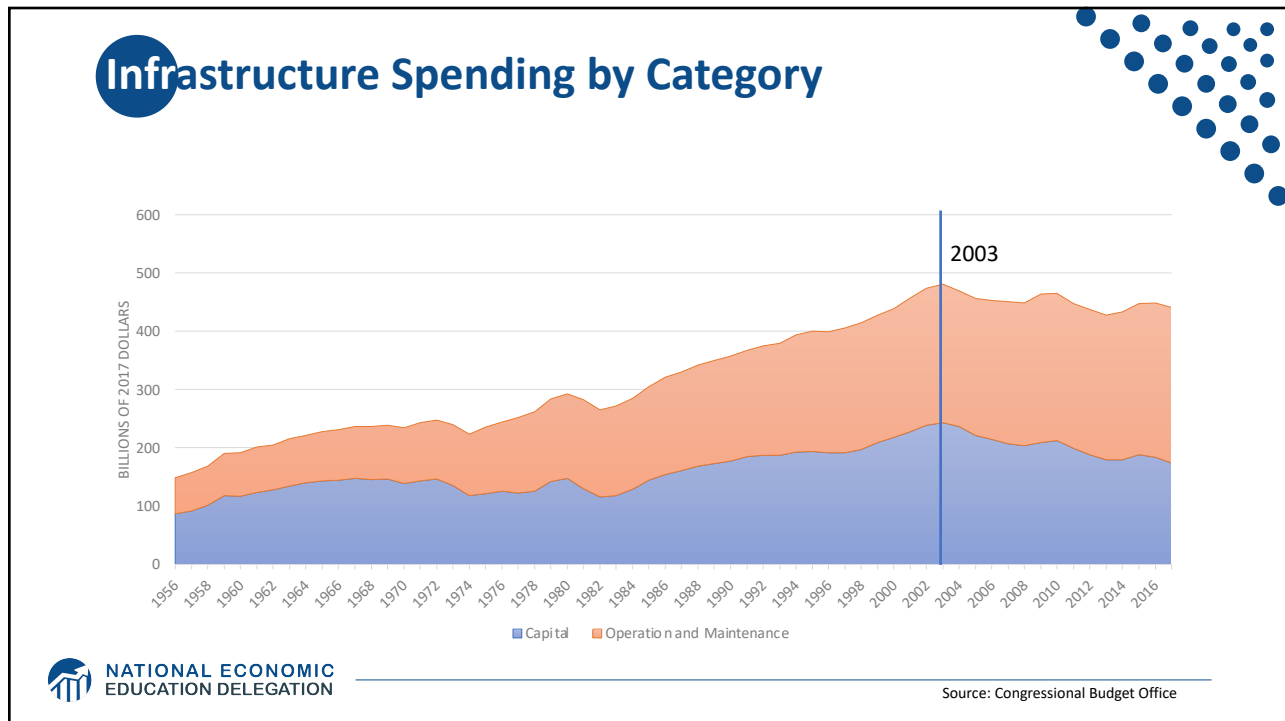
Spending on Infrastructure as Share of GDP



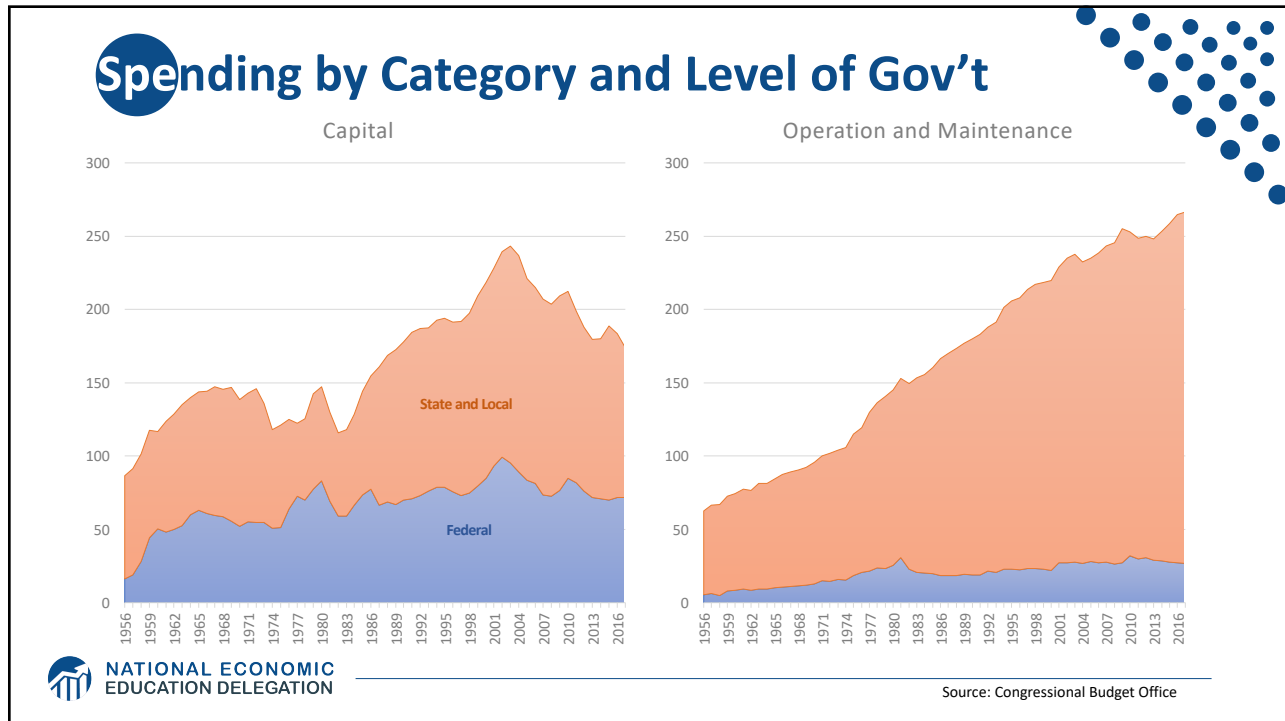
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Federal vs. State and Local Gov't Roles in Infrastructure Investment

Mode	Typical Maximum Federal Share of Total Spending	Decision making roles of Federal, State and Local Gov'ts
Highways	80% of capital	State and local gov'ts choose projects, following federal rules and conditions.
Mass Transit	80% of capital, 50% of operations	State and local gov'ts choose projects, following federal rules and conditions.
Rail	Not applicable	Regulatory
Aviation	75%-90% of capital	State and local gov'ts choose projects, following federal rules and conditions; Federal gov't designs the national aviation system.
Water Transportation	40%-100% of construction, 50%-100% of operations	Federal gov't chooses water projects with Congressional approval.

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Federal Support for State and Local Infrastructure

- **Federal government provides to state and local governments**
 - major financial support for highways, mass transit, aviation, and water utilities.
 - relatively little financial support for water infrastructure.



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Funding vs. Financing Infrastructure Investment

- **Funding**
 - Spending current resources
- **Financing**
 - Issue bonds to be repaid in future.
 - Attractive option if government doesn't have funds now.
 - Limits future availability of funds.
- **1/3rd of public investment between 2007-16 involved federally supported financing.**



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Sources of Federal Infrastructure Financing

- **Discretionary spending**
 - Subject to appropriation
 - Capitalization grants for state banks and
 - Fund the net subsidy costs of direct federal credit programs

- **Direct spending**
 - Authorization of mandatory spending
 - 2009-10 Build America Bonds program for transportation and water projects
 - Future programs of tax credit bonds

- **Federal tax exemption for the interest paid on various bonds.**



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Federal Financing of State and Local Infrastructure

- **50%+ state and local infrastructure spending financed through**
 - Bonds that provide federal tax preferences or
 - Federally supported loan programs

- **Examples:**
 - Tax exempt bonds ← Most widely used
 - State revolving funds and infrastructure banks (or state banks)
 - Direct Loans -- loans made using banks' capital funds
 - Leveraged Loans -- using the proceeds of bank issued tax-exempt bonds
 - Tax credit bonds
 - Direct federal credit programs



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Fiscal Substitution of Federal Infrastructure Investment

- A \$1 increase in federal highway grants, reduces state and local spending by 20-80 cents.
- The effect will vary depending on
 - Fiscal condition of state and local governments,
 - Whether federal spending change is permanent or temporary,
 - Magnitude of the spending change,
 - Direction of the change.



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What About Private Sector Investment?

- State and local governments own almost all of the nation's transportation and water infrastructure.
- Most of the private-sector investment in these occurs through public-private partnerships for publicly owned infrastructure.



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What Is a Public-Private Partnership?

- Per Engel et al. (2011)

“an agreement by which the government contracts a private company to build or improve infrastructure works and to subsequently maintain and operate them for an extended period (for example, 30 years) in exchange for a stream of revenues during the life of the contract”

- New federal investment tends to favor new construction.
- Traditional procurement separates design, construction and maintenance aspects.
- Contractors involved in new construction not incentivized to build to minimize long term maintenance costs.
- PPP helps correct this incentive problem.



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Types of PPP contracts

- **PPP contracts differ based on the amount of risk transferred from the public to the private sector:**

- Design-Build (DB)
- Design-Build-Operate-Maintain (DBOM)
- Design-Build-Finance-Operate-Maintain (DBFOM)
- Similarly, we can have DBF, DBFM, etc.



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Few Public-Private Partnerships in the US

- Colorado I-70 Project
- Denver FasTracks commuter and light rail project in Colorado,
- Goethals Bridge reconstruction project linking New York City and New Jersey
- Bayonne Water Joint Venture LLC project, a water and wastewater PPP in New Jersey
- Automated People Mover (APM) project at Los Angeles International Airport (LAX)
- LaGuardia Airport Terminal B P3 project



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An Alternative Financing Tool – User Fees

- **Make those who use infrastructure more heavily, pay for it.**
 - User fees help in appropriately rationing assets to the space.
 - Help in demand management where congestion is an issue



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An Alternative Financing Tool – User Fees

• Singapore’s congestion pricing model

- Singapore -- an island nation with land area of 250 sq. miles
- Limited street capacity in the central business area
- Heavy congestion
- Electronic Road Pricing (ERP) System launched in 1998
 - o variable pricing designed to respond to congestion in real-time
- Complementary policies to ERP
 - o Parking fees inside the restriction zone doubled
 - o Buses and bus frequency increased
 - o HOV+4 lanes established
 - o 15,000 park-and-ride spaces were established outside the restriction zone



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Another Aspect of Infrastructure – Broadband

- Talk of a digital divide ubiquitous.
 - Especially considering the current pandemic.
- 21 million+ Americans lack meaningful access to the internet.
 - Meaningful access: 25 Mbps download and 3 Mbps upload.
 - 14.5 million have no access at all.
- Lack of access more common among the less educated, low income, living in rural or suburban areas.
- 9 million+ school children lacked internet access for online schoolwork.



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Broadband Access

- Modern-day equivalent of the interstate highway system.
- Lack of access not just a rural problem.
 - In 2016, 57% of households in Detroit, MI;
 - 49% in Memphis, TN and
 - 48% in Cleveland, OH without fixed broadband.
- Digital redlining within cities.
- Where available, service is often limited to a single service provider – natural monopolies.
 - Due to high up-front fixed costs of laying fiber optic lines.

Solutions to the Access Problem

- 2021 Infrastructure Bill
- FCC Launched a \$20 billion Rural Digital Opportunity Fund in February 2020
 - \$6 million budget
 - Target census blocks that were without 25/3 Mbps broadband.
- Taking matters into their own hands, cities and communities:
 - Building municipal infrastructure and cooperatives providing broadband
 - Despite legal barriers or bans on publicly owned networks in 19 states
 - 850+ communities served by a municipal network or cooperative
- Community-owned networks are less expensive and have more transparent pricing than private ISPs – Harvard Study

Technological Advancements of the Future to the Rescue?

- **Low Earth Orbit (LEO) satellite internet**

- On June 13, 2020 Elon Musk's SpaceX launched 58 satellites into low earth orbit as part of the Starlink program.
- Aims to provide low-latency (less lag) satellite internet.
- Better internet coverage than traditional communications satellites.
- Could potentially provide high quality internet to homes and businesses without access to cable, fiber, or reliable cellular internet.



Enormous Economic Benefits to Access

- **Individual benefits:**

- Better health and life outcomes.
 - o Access to health and education online.
 - o Job search and development of digital skills.
- Higher property values.
- Increased population and job growth.
 - o Higher rates of business formation.

- **Broader economic benefits:**

- World Bank
 - o 10% increase in access yields a 1.2% jump in real incomes.
- Indiana
 - o ROI = 300-400%.



Pace of Investment



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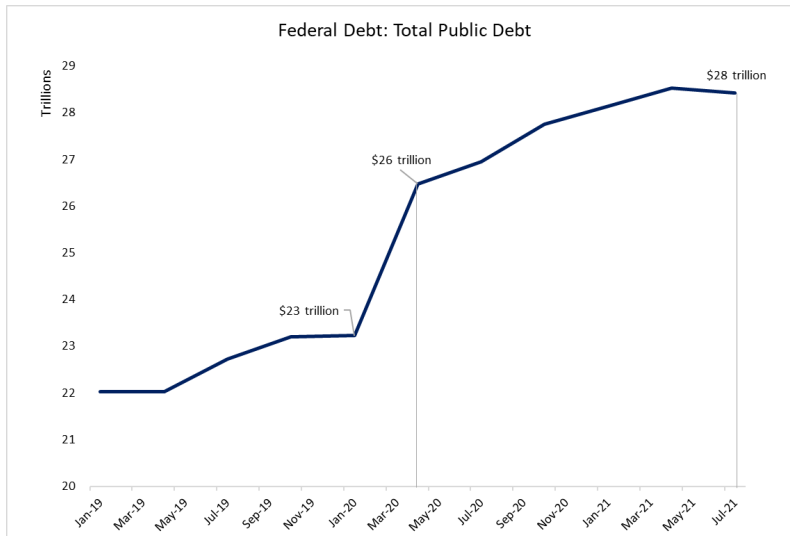
Too Much, Too Soon? Too Little, Too Late?

- **Was the recent infrastructure package appropriate?**
- **The United States has enormous needs.**
 - Basic infrastructure – bridges, roads, etc.
 - Other:
 - General R&D: 2% of GDP in the 1950s, currently 0.75%.
- **Is now the time to borrow extensively?**
 - Have just borrowed > \$4 Trillion.
 - Interest rates are very low (but rising).
- **Given the state of our infrastructure, the ROR can be very high.**



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COVID Borrowing

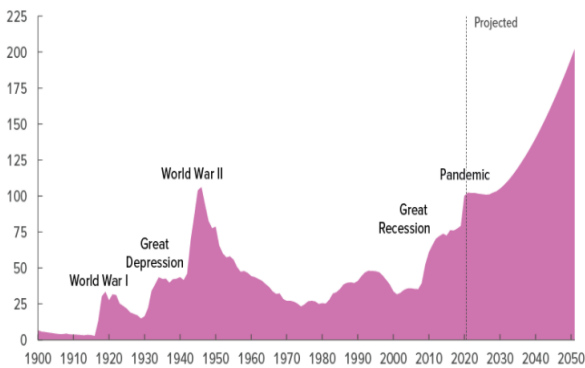


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Debt Outlook is Troublesome

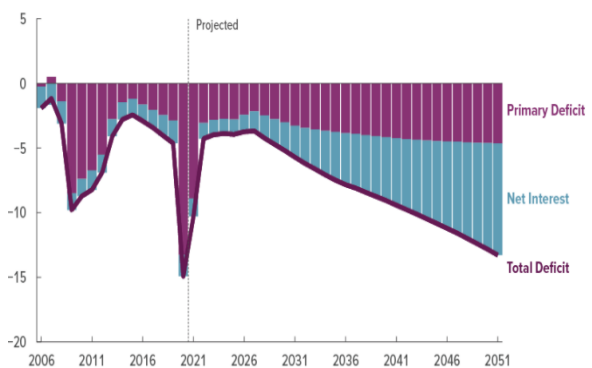
Federal Debt Held by the Public, 1900 to 2051

Percentage of Gross Domestic Product



Total Deficits, Primary Deficits, and Net Interest

Percentage of Gross Domestic Product



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Summary

- Infrastructure investment is important.
- Current state of US infrastructure – leaves a lot to be desired.
- Public infrastructure investment can play a vital role in long run growth.
 - Improve mobility.
 - Raise private capital productivity.
 - Improve health.
- May not be ideal as short-term stimulus.
- Private sector involvement via the market process can promote innovation and efficiency.
- Local access issues may sometimes be better resolved locally than federally.
 - Reforms needed to make the process less cumbersome



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Thank you!

Any Questions?

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Available NEED Topics Include:

- Coronavirus Economics
- US Economy
- Climate Change
- Economic Inequality
- Economic Mobility
- Trade and Globalization
- Minimum Wages
- Immigration Economics
- Housing Policy
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- Black-White Wealth Gap
- Autonomous Vehicles
- US Social Policy

